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Doctoral Dissertation

Emerging concepts for monitoring and control of hygienic food production

submitted by

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Abstract

Inadequate hygiene practices can lead to microbial contamination of food, resulting in food spoilage or foodborne illness. Thus, the microbial contamination risk associated with biofilm growth on surfaces and airborne transmission pathways was investigated.

To develop adequate biofilm control and detection methods, the mechanisms behind bacterial adhesion and biofilm formation are fundamental. Therefore, the interplay between biofilm growth and surface characteristics on food-contact and non-food contact surfaces, taking into account any applied antimicrobial substances, was investigated.

Above all, early and rapid detection and effective control methods are critical to minimize or prevent foodborne illness outbreaks or economic losses that may be caused by biofilm formation or airborne pathogens.

In the course of this thesis, state-of-the-art detection methods and the potential of flow cytometry (FCM) detection were proposed. Since the use of FCM for food-related applications is still limited, an optimized method with the assistance of pulsed electric fields (PEFs) was suggested. The rapid PEF-assisted FCM detection allows the use of non-hazardous alternative fluorochromes instead of conventional toxic ones to avoid contamination of the system and potential risk to human health. This was the first study using PEF as a pretreatment method for FCM detection with non-hazardous dyes.

To use this advanced approach, the respective methods, FCM and PEF, needed to be developed and optimized. First, a rapid fluorescence-based single staining method was proposed to assess intermediate cellular states of *E. coli* after PEF treatment, which could be used for rapid screening of PEF treatment parameters and associated effects. The suitability of different PEF treatment chambers for potential applications in life sciences was also investigated. It can be derived that the electrical conductivity of the media, the treatment chamber design, and the electrode area must be carefully considered for its intended use.

Rapid detection methods like PEF-assisted FCM can be used to detect anormal or high levels of microorganisms in the production environment, however appropriate control strategies are required to protect the food from any potential contamination. Based on a case study conducted in bakery production, an easy-to-apply and cost-effective protection concept to control the spread of airborne microbes, based on filter-fan units (FFUs), was simulated. Based on the simulation, the relative contamination levels were significantly reduced (99.94%) by an optimized FFU concept. Hence the cake line was protected against sedimentation of airborne particles.

This thesis aims to investigate emerging concepts for monitoring and controlling hygienic food production to minimize or avoid foodborne disease outbreaks and economic losses due to pathogens and food spoilage microorganisms.